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An Experimental Study on Optimum Replacement Level of Fine Aggregate by Steel Slag in Concrete

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***Abstract*—** The M_{40} concrete with high volume steel slag sand replacement for fine aggregate are examined in the present study.The effect of the amount of steel slag was evaluated adapting 10%, 20%, 30%, 40%, 50% cement replacement. Quality is determined from the experimental test values. For the best proportion of steel slag sand is partially replaced for fine aggregate in various percentages of 10%, 20%, 30%, 40%, 50%. The material properties were carried out experimentally. according to material properties compressive strength, flexural strength, split tensile strength and modulus of elasticity were found experimentally. The results are found to be increasing with the increase in the percentage of steel slag, and it is concluded that the steel slag can be partially utilized in concrete.

Keywords- steel slag sand, fine aggregate, split tensile strength, modulus of elasticity

I. INTRODUCTION

Concrete is the most widely used material for construction since several years. It is the choice of material in construction industry due to its inherent properties of versatility, durability and ease of construction. In the present scenario of environmental protection and accomplishment of meeting huge infrastructural requirements, emerging technologies like high performance concrete, green concrete, etc., are of preference. It has undergone many changes from time to time for acquiring better properties. The coarse aggregate in concrete may be gravel, crushed granite, sand stone, basalt or barite, etc. This project initiative gives the solution to solid waste disposal and also reduces the natural sand exploitation.

Large quantities of waste materials and by-products (silica fume, fly ash, slag) are generated from manufacturing processes and service industries. As a result, proper disposal of such materials become one of the major environmental concerns in the world. With the increasing awareness about the environment, scarcity of landfill space and due to its ever increasing cost, waste utilization has become an attractive alternative to disposal. The incorporation of industrial by-products in concrete can significantly enhance its basic properties in both the fresh and hardened states. The aim of the present study is to utilize the industrial waste in concrete effectively. In this project slag from steel industry is used to replace for fine aggregate. The strength properties of concrete are determined with the various replacement level of steel slag with fine aggregate. This project focuses on the optimization of replacement of steel slag with fine aggregate in the concrete mix of M40 grade.

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II. MATERIALS USED

A. Cement Ordinary portland Cement (OPC) conforming to IS: 8112 – 1989, having a specific gravity of 3.15 was made use of, in the casting of the specimens.

B. Fine Aggregate The fine aggregate (sand) used was clean dry sand. The sand was sieved in 4.75mm Sieve to remove all pebbles.

C. Coarse Aggregate Hard stones of size less than 20mm were used as coarse aggregate.

D. Steel SlagSteel slag is a byproduct of steel production. The main components of steel slag are lime and silica, which help steel slag remain an environmentally friendly product. Under certain conditions, steel slag can become unstable.

Steel Slag Physical Composition

Color	Light to dark brown
Shape	Highly angular
Bulk density	1911.11 kg/m^3
pH (in water)	8
Combustibility	Non-combustible
Surface Texture	Rough
Loss on Abrasion	Less than 1

Steel Slag Chemical Composition

Element	Percent by Weight
CaO	40 – 52
SiO_2	10-19
FeO	10-40 (70 - 80% FeO, 20 - 30% Fe_2O_3)
MnO	5-8
MgO	5-10
Al_2O_3	1-3
P_2O_5	0.5-1
S	< 0.1
Metallic Fe	0.5 – 10

III. HARDENED TEST ON CONCRETE

A. *Compression Test*

After 7 days,14 days and 28 days of curing, three 150mm cubes of a concrete mixture were tested using the compression machine. These cubes were loaded on their sides during compression testing such that the load was exerted perpendicularly to the direction of casting. The average value of the three cubes was taken as the compressive strength.

B. *Split Tensile Test*

The test was carried out by placing the cylindrical specimen horizontally between the loading surfaces of a compression testing machine and load is applied until the initial crack of the specimen occurs, along the diameter.

C. *Flexural Strength*

The test was carried out on 100mm X100mm X500mm size prism. The test was carried out on a universal testing machine of 400kN capacity, adopting two point loading. The bearing surfaces of the supporting and loading rollers are wiped clean, and

any loose sand or other material removed from the surfaces of the specimen. The specimen was placed in the UTM and that the load was applied to the uppermost surface as cast in the mould, along two lines spaced 20cm apart. The load was increased until the specimen fails, and the maximum load applied to the specimen during the test was recorded and appearance of the fractured faces of concrete was noted.

D. *Modulus of Elasticity of Concrete*

The cylinder specimen is of the size 300 mm x 150mm, the Young's modulus of concrete is determined by using Compression Testing Machine.

Compressive Strength results		
SpecimenDetails	Compressive Strength at7 days (N/mm^2)	Compressive Strength at28days (N/mm^2)
A	31.80	48.20
B	32.10	48.50
C	32.60	48.64
D	33.10	48.90
E	33.90	49.40
F	33.50	48.60

Split Tensile Strength		
SpecimenDetails	Split Tensile Strength at 7 days (N/mm^2)	Split Tensile Strength at 28days (N/mm^2)
A	3.18	4.25
B	3.21	4.28
C	3.24	4.34
D	3.26	4.36
E	3.32	4.42
F	3.29	4.39

Flexural Strength Results		
SpecimenDetails	Flexural Strength at 7 days (N/mm^2)	Flexural Strength at 28 days (N/mm^2)
A	3.15	4.84
B	3.18	4.87
C	3.20	4.90
D	3.24	4.92
E	3.28	4.94
F	3.23	4.92

Young's Modulus		
SpecimenDetails	Young's Modulus at 7days (N/mm^2)	Young's Modulus at 28days (N/mm^2)
A	21.30	31.60
B	21.36	31.66
C	21.47	31.77
D	21.53	31.83
E	21.67	31.97
F	21.60	31.80

IV. CONCLUSION

- From the test results, it is observed that 40% replacement level of natural sand with steel slag gives equal strength as conventional concrete. So, it is

concluded that optimum replacement level of fine aggregate with steel slag as 40%.

- Since, Salem is a steel producing zone and the steel slag produced are abundant, this project initiative will give solution to solid waste disposal and also reduces the natural sand exploitation. Hence this attempt towards eco-friendly built environment is need of hour.

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